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Jameco Part Number 213073



- **Low Power Consumption**
- **Wide Common-Mode and Differential Voltage Ranges**
- **Low Input Bias and Offset Currents**
- **Output Short-Circuit Protection**
- **Low Total Harmonic Distortion 0.003% Typ**
- **Low Noise $V_n$ = 18 nV/$\sqrt{Hz}$ Typ at f = 1 kHz**
- **High Input Impedance . . . JFET Input Stage**
- **Internal Frequency Compensation**
- **Latch-Up-Free Operation**
- **High Slew Rate . . . 13 V/$\mu$s Typ**
- **Common-Mode Input Voltage Range Includes $V_{CC+}$**

## description

The JFET-input operational amplifiers in the TL07_ series are designed as low-noise versions of the TL08_ series amplifiers with low input bias and offset currents and fast slew rate. The low harmonic distortion and low noise make the TL07_ series ideally suited for high-fidelity and audio preamplifier applications. Each amplifier features JFET inputs (for high input impedance) coupled with bipolar output stages integrated on a single monolithic chip.

The C-suffix devices are characterized for operation from 0°C to 70°C. The I-suffix devices are characterized for operation from –40°C to 85°C. The M-suffix devices are characterized for operation over the full military temperature range of –55°C to 125°C.

**AVAILABLE OPTIONS**

| $T_A$ | $V_{IO}$max AT 25°C | PACKAGE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | SMALL OUTLINE (D)† | CHIP CARRIER (FK) | CERAMIC DIP (J) | CERAMIC DIP (JG) | PLASTIC DIP (N) | PLASTIC DIP (P) | TSSOP PACKAGE (PW) | FLAT PACKAGE (W) |
| 0°C to 70°C | 10 mV | TL071CD | — | — | — | — | TL071CP | TL071CPWLE | — |
| | 6 mV | TL071ACD | | | | | TL071ACP | — | |
| | 3 mV | TL071BCD | | | | | TL071BCP | — | |
| | 10 mV | TL072CD | — | — | — | — | TL072CP | TL072CPWLE | — |
| | 6 mV | TL072ACD | | | | | TL072ACP | — | |
| | 3 mV | TL072BCD | | | | | TL072BCP | — | |
| | 10 mV | TL074CD | — | — | — | TL074CN | — | TL074CPWLE | — |
| | 6 mV | TL074ACD | | | | TL074ACN | | — | |
| | 3 mV | TL074BCD | | | | TL074BCN | | — | |
| –40°C to 85°C | 6 mV | TL071ID | — | — | — | — | TL071IP | — | — |
| | | TL072ID | | | | — | TL072IP | | |
| | | TL074ID | | | | TL074IN | — | | |
| –55°C to 125°C | 6 mV | — | TL071MFK | — | TL071MJG | — | — | — | — |
| | 6 mV | | TL072MFK | — | TL072MJG | — | TL072MP | | — |
| | 9 mV | | TL074MFK | TL074MJ | — | TL074MN | — | | TL074MW |

† The D package is available taped and reeled. Add the suffix R to the device type (e.g., TL071CDR). The PW package is only available left-ended taped and reeled (e.g., TL072CPWLE).

Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

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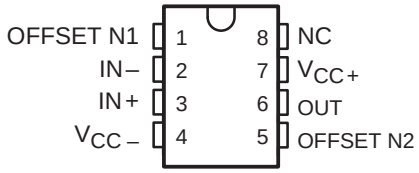
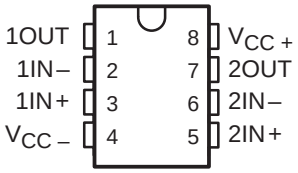
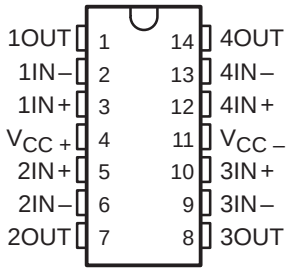
**TL071, TL071A, TL071B**
**D, JG, P, OR PW PACKAGE**
**(TOP VIEW)**



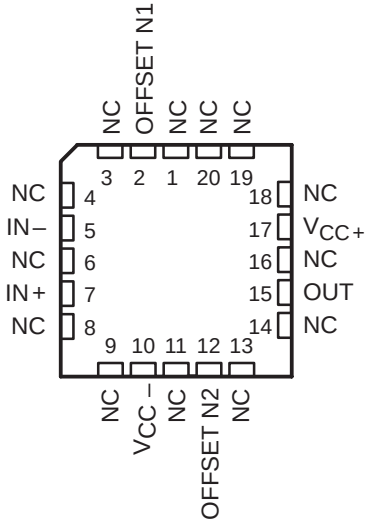

**TL072, TL072A, TL072B**
**D, JG, P, OR PW PACKAGE**
**(TOP VIEW)**



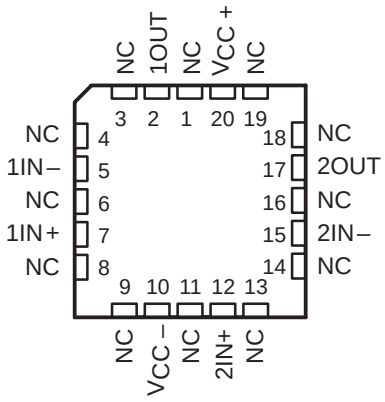

**TL074, TL074A, TL074B**
**D, J, N, OR PW PACKAGE**
**TL074 . . . W PACKAGE**
**(TOP VIEW)**



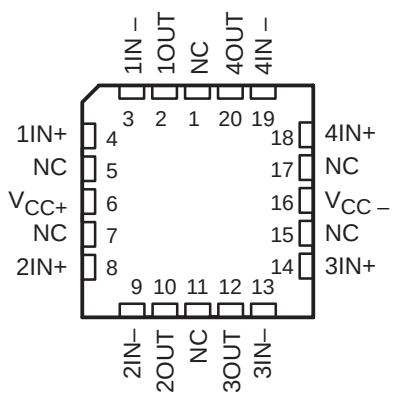

**TL071**
**FK PACKAGE**
**(TOP VIEW)**




**TL072**
**FK PACKAGE**
**(TOP VIEW)**



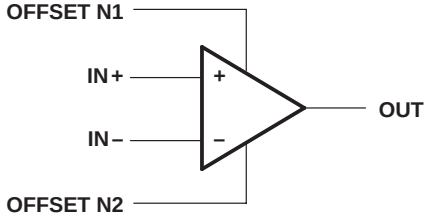

**TL074**
**FK PACKAGE**
**(TOP VIEW)**



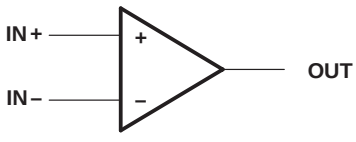

NC – No internal connection

## symbols

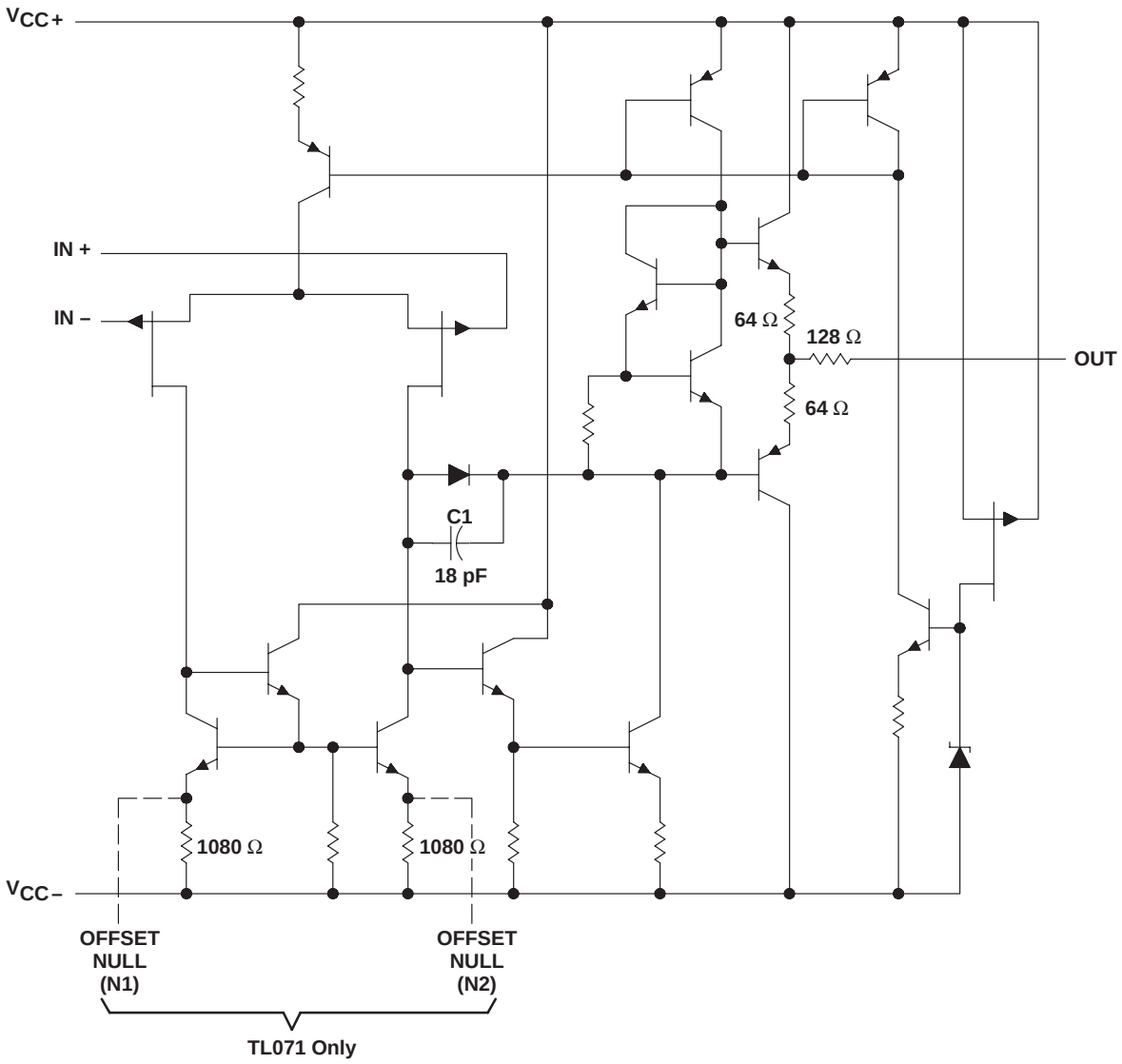
**TL071**




**TL072 (each amplifier)**
**TL074 (each amplifier)**



## schematic (each amplifier)




All component values shown are nominal.

| COMPONENT COUNT† | | | |
|---|---|---|---|
| COMPONENT TYPE | TL071 | TL072 | TL074 |
| Resistors | 11 | 22 | 44 |
| Transistors | 14 | 28 | 56 |
| JFET | 2 | 4 | 6 |
| Diodes | 1 | 2 | 4 |
| Capacitors | 1 | 2 | 4 |
| epi-FET | 1 | 2 | 4 |

† Includes bias and trim circuitry

### absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage, $V_{CC+}$ (see Note 1) . . . . . 18 V
Supply voltage, $V_{CC-}$ (see Note 1) . . . . . –18 V
Differential input voltage, $V_{ID}$ (see Note 2) . . . . . ±30 V
Input voltage, $V_I$ (see Notes 1 and 3) . . . . . ±15 V
Duration of output short circuit (see Note 4) . . . . . unlimited
Continuous total power dissipation . . . . . See Dissipation Rating Table
Operating free-air temperature range, $T_A$: C suffix . . . . . 0°C to 70°C
I suffix . . . . . –40°C to 85°C
M suffix . . . . . –55°C to 125°C
Storage temperature range . . . . . –65°C to 150°C
Case temperature for 60 seconds: FK package . . . . . 260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: J, JG, or W package . . . . . 300°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D, N, P, or PW package . . . . . 260°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES: 1. All voltage values, except differential voltages, are with respect to the midpoint between $V_{CC+}$ and $V_{CC-}$.
2. Differential voltages are at IN+ with respect to IN–.
3. The magnitude of the input voltage must never exceed the magnitude of the supply voltage or 15 V, whichever is less.
4. The output may be shorted to ground or to either supply. Temperature and/or supply voltages must be limited to ensure that the dissipation rating is not exceeded.

**DISSIPATION RATING TABLE**

| PACKAGE | $T_A \le 25°C$ POWER RATING | DERATING FACTOR | DERATE ABOVE $T_A$ | $T_A = 70°C$ POWER RATING | $T_A = 85°C$ POWER RATING | $T_A = 125°C$ POWER RATING |
|---|---|---|---|---|---|---|
| D (8 pin) | 680 mW | 5.8 mW/°C | 33°C | 465 mW | 378 mW | N/A |
| D (14 pin) | 680 mW | 7.6 mW/°C | 60°C | 604 mW | 490 mW | N/A |
| FK | 680 mW | 11.0 mW/°C | 88°C | 680 mW | 680 mW | 273 mW |
| J | 680 mW | 11.0 mW/°C | 88°C | 680 mW | 680 mW | 273 mW |
| JG | 680 mW | 8.4 mW/°C | 69°C | 672 mW | 546 mW | 210 mW |
| N | 680 mW | 9.2 mW/°C | 76°C | 680 mW | 597 mW | N/A |
| P | 680 mW | 8.0 mW/°C | 65°C | 640 mW | 520 mW | N/A |
| PW (8 pin) | 525 mW | 4.2 mW/°C | 70°C | 525 mW | N/A | N/A |
| PW (14 pin) | 700 mW | 5.6 mW/°C | 70°C | 700 mW | N/A | N/A |
| W | 680 mW | 8.0 mW/°C | 65°C | 640 mW | 520 mW | 200 mW |

## electrical characteristics, $V_{CC\pm}$ = ±15 V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS† | $T_A$‡ | TL071C TL072C TL074C | | | TL071AC TL072AC TL074AC | | | TL071BC TL072BC TL074BC | | | TL071I TL072I TL074I | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_O$ = 0, $R_S$ = 50 Ω | 25°C | | 3 | 10 | | 3 | 6 | | 2 | 3 | | 3 | 6 | mV |
| | | | Full range | | | 13 | | | 7.5 | | | 5 | | | 8 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | $V_O$ = 0, $R_S$ = 50 Ω | Full range | | 18 | | | 18 | | | 18 | | | 18 | | µV/°C |
| $I_{IO}$ | Input offset current | $V_O$ = 0 | 25°C | | 5 | 100 | | 5 | 100 | | 5 | 100 | | 5 | 100 | pA |
| | | | Full range | | | 10 | | | 2 | | | 2 | | | 2 | nA |
| $I_{IB}$ | Input bias current§ | $V_O$ = 0 | 25°C | | 65 | 200 | | 65 | 200 | | 65 | 200 | | 65 | 200 | pA |
| | | | Full range | | | 7 | | | 7 | | | 7 | | | 20 | nA |
| $V_{ICR}$ | Common-mode input voltage range | | 25°C | ±11 | –12 to 15 | | ±11 | –12 to 15 | | ±11 | –12 to 15 | | ±11 | –12 to 15 | | V |
| $V_{OM}$ | Maximum peak output voltage swing | $R_L$ = 10 kΩ | 25°C | ±12 | ±13.5 | | ±12 | ±13.5 | | ±12 | ±13.5 | | ±12 | ±13.5 | | V |
| | | $R_L$ ≥ 10 kΩ | Full range | ±12 | | | ±12 | | | ±12 | | | ±12 | | | |
| | | $R_L$ ≥ 2 kΩ | | ±10 | | | ±10 | | | ±10 | | | ±10 | | | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ±10 V, $R_L$ ≥ 2 kΩ | 25°C | 25 | 200 | | 50 | 200 | | 50 | 200 | | 50 | 200 | | V/mV |
| | | | Full range | 15 | | | 25 | | | 25 | | | 25 | | | |
| $B_1$ | Unity-gain bandwidth | | 25°C | | 3 | | | 3 | | | 3 | | | 3 | | MHz |
| $r_i$ | Input resistance | | 25°C | | $10^{12}$ | | | $10^{12}$ | | | $10^{12}$ | | | $10^{12}$ | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, $V_O$ = 0, $R_S$ = 50 Ω | 25°C | 70 | 100 | | 75 | 100 | | 75 | 100 | | 75 | 100 | | dB |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | $V_{CC}$ = ±9 V to ±15 V, $V_O$ = 0, $R_S$ = 50 Ω | 25°C | 70 | 100 | | 80 | 100 | | 80 | 100 | | 80 | 100 | | dB |
| $I_{CC}$ | Supply current (each amplifier) | $V_O$ = 0, No load | 25°C | | 1.4 | 2.5 | | 1.4 | 2.5 | | 1.4 | 2.5 | | 1.4 | 2.5 | mA |
| $V_{O1}/V_{O2}$ | Crosstalk attenuation | $A_{VD}$ = 100 | 25°C | | 120 | | | 120 | | | 120 | | | 120 | | dB |

† All characteristics are measured under open-loop conditions with zero common-mode voltage unless otherwise specified.
‡ Full range is $T_A$ = 0°C to 70°C for TL07_C,TL07_AC, TL07_BC and is $T_A$ = –40°C to 85°C for TL07_I.
§ Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive as shown in Figure 4. Pulse techniques must be used that maintain the junction temperature as close to the ambient temperature as possible.

## electrical characteristics, $V_{CC\pm}$ = ±15 V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS† | $T_A$‡ | TL071M TL072M | | | TL074M | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_O$ = 0, $R_S$ = 50 Ω | 25°C | | 3 | 6 | | 3 | 9 | mV |
| | | | Full range | | | 9 | | | 15 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | $V_O$ = 0, $R_S$ = 50 Ω | Full range | | 18 | | | 18 | | μV/°C |
| $I_{IO}$ | Input offset current | $V_O$ = 0 | 25°C | | 5 | 100 | | 5 | 100 | pA |
| | | | Full range | | | 20 | | | 20 | nA |
| $I_{IB}$ | Input bias current‡ | $V_O$ = 0 | 25°C | | 65 | 200 | | 65 | 200 | pA |
| | | | | | | 50 | | | 50 | nA |
| $V_{ICR}$ | Common-mode input voltage range | | 25°C | ±11 | –12 to 15 | | ±11 | –12 to 15 | | V |
| $V_{OM}$ | Maximum peak output voltage swing | $R_L$ = 10 kΩ | 25°C | ±12 | ±13.5 | | ±12 | ±13.5 | | V |
| | | $R_L$ ≥ 10 kΩ | Full range | ±12 | | | ±12 | | | |
| | | $R_L$ ≥ 2 kΩ | | ±10 | | | ±10 | | | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ±10 V, $R_L$ ≥ 2 kΩ | 25°C | 35 | 200 | | 35 | 200 | | V/mV |
| | | | | 15 | | | 15 | | | |
| $B_1$ | Unity-gain bandwidth | $T_A$ = 25°C | | | 3 | | | 3 | | MHz |
| $r_i$ | Input resistance | $T_A$ = 25°C | | | $10^{12}$ | | | $10^{12}$ | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, $V_O$ = 0, $R_S$ = 50 Ω | 25°C | 80 | 86 | | 80 | 86 | | dB |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | $V_{CC}$ = ±9 V to ±15 V, $V_O$ = 0, $R_S$ = 50 Ω | 25°C | 80 | 86 | | 80 | 86 | | dB |
| $I_{CC}$ | Supply current (each amplifier) | $V_O$ = 0, No load | 25°C | | 1.4 | 2.5 | | 1.4 | 2.5 | mA |
| $V_{O1}/V_{O2}$ | Crosstalk attenuation | $A_{VD}$ = 100 | 25°C | | 120 | | | 120 | | dB |

† Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive as shown in Figure 4. Pulse techniques must be used that will maintain the junction temperature as close to the ambient temperature as possible.

‡ All characteristics are measured under open-loop conditions with zero common-mode voltage unless otherwise specified. Full range is $T_A$ = –55°C to 125°C.

## operating characteristics, $V_{CC\pm} = \pm 15$ V, $T_A = 25°C$

| PARAMETER | | TEST CONDITIONS | | TL07xM | | | ALL OTHERS | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $V_I$ = 10 V, $C_L$ = 100 pF, | $R_L$ = 2 kΩ, See Figure 1 | 5 | 13 | | 8 | 13 | | V/μs |
| $t_r$ | Rise time overshoot factor | $V_I$ = 20 mV, $C_L$ = 100 pF, | $R_L$ = 2 kΩ, See Figure 1 | | 0.1 | | | 0.1 | | μs |
| | | | | | 20% | | | 20% | | |
| $V_n$ | Equivalent input noise voltage | $R_S$ = 20 Ω | f = 1 kHz | | 18 | | | 18 | | nV/√Hz |
| | | | f = 10 Hz to 10 kHz | | 4 | | | 4 | | μV |
| $I_n$ | Equivalent input noise current | $R_S$ = 20 Ω, | f = 1 kHz | | 0.01 | | | 0.01 | | pA/√Hz |
| THD | Total harmonic distortion | $V_I$rms = 6 V, $R_L \geq 2$ kΩ, f = 1 kHz | $A_{VD}$ = 1, $R_S \leq 1$ kΩ, | | 0.003% | | | 0.003% | | |

## PARAMETER MEASUREMENT INFORMATION

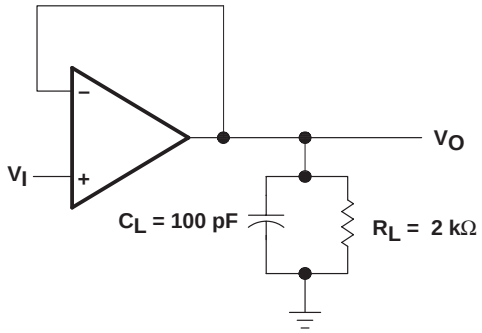



**Figure 1. Unity-Gain Amplifier**

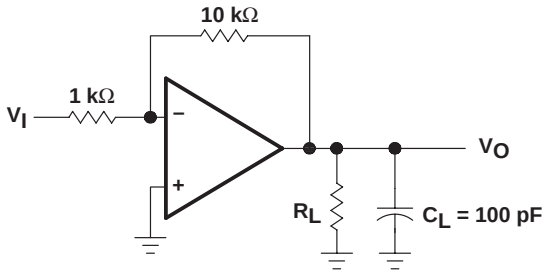



**Figure 2. Gain-of-10 Inverting Amplifier**

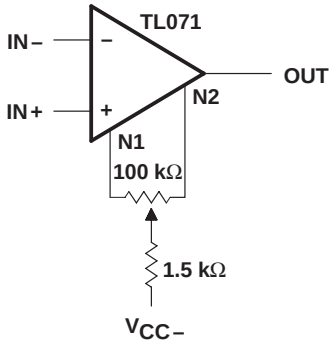



**Figure 3. Input Offset Voltage Null Circuit**

## TYPICAL CHARACTERISTICS

### Table of Graphs

| | | | FIGURE |
|---|---|---|---|
| $I_{IB}$ | Input bias current | vs Free-air temperature | 4 |
| $V_{OM}$ | Maximum output voltage | vs Frequency<br>vs Free-air temperature<br>vs Load resistance<br>vs Supply voltage | 5, 6, 7<br>8<br>9<br>10 |
| $A_{VD}$ | Large-signal differential voltage amplification | vs Free-air temperature<br>vs Frequency | 11<br>12 |
| | Phase shift | vs Frequency | 12 |
| | Normalized unity-gain bandwidth | vs Free-air temperature | 13 |
| | Normalized phase shift | vs Free-air temperature | 13 |
| CMRR | Common-mode rejection ratio | vs Free-air temperature | 14 |
| $I_{CC}$ | Supply current | vs Supply voltage<br>vs Free-air temperature | 15<br>16 |
| $P_D$ | Total power dissipation | vs Free-air temperature | 17 |
| | Normalized slew rate | vs Free-air temperature | 18 |
| $V_n$ | Equivalent input noise voltage | vs Frequency | 19 |
| THD | Total harmonic distortion | vs Frequency | 20 |
| | Large-signal pulse response | vs Time | 21 |
| $V_O$ | Output voltage | vs Elapsed time | 22 |

## TYPICAL CHARACTERISTICS†

**INPUT BIAS CURRENT vs FREE-AIR TEMPERATURE**

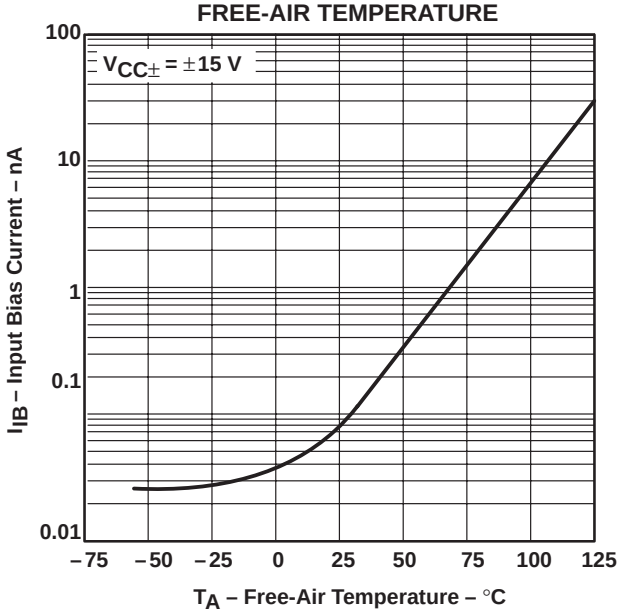



Figure 4

**MAXIMUM PEAK OUTPUT VOLTAGE vs FREQUENCY**

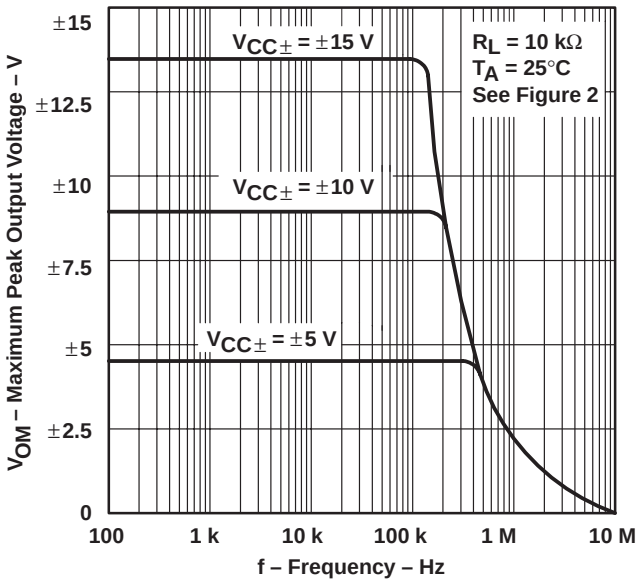



Figure 5

**MAXIMUM PEAK OUTPUT VOLTAGE vs FREQUENCY**

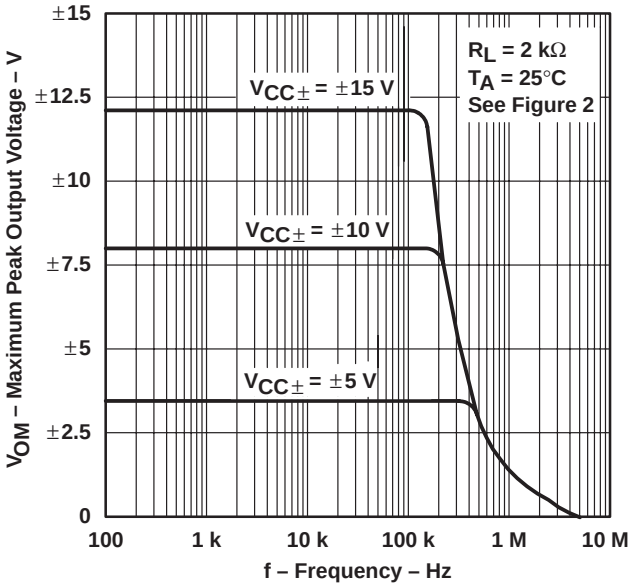



Figure 6

**MAXIMUM PEAK OUTPUT VOLTAGE vs FREQUENCY**

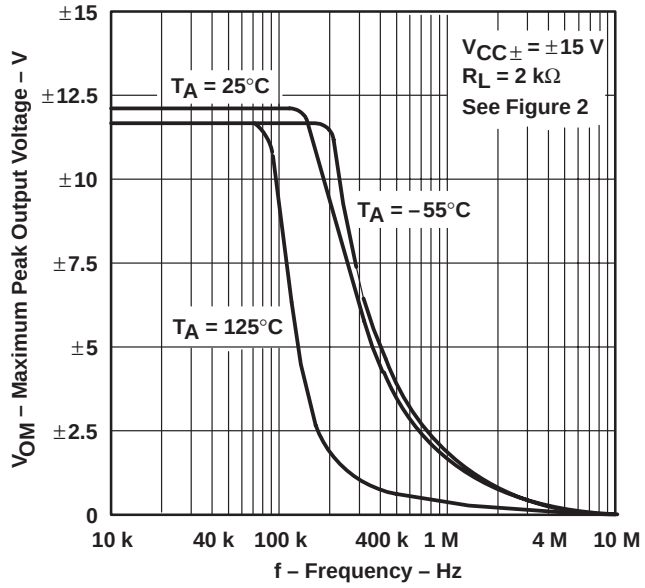



Figure 7

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

## TYPICAL CHARACTERISTICS†

**MAXIMUM PEAK OUTPUT VOLTAGE vs FREE-AIR TEMPERATURE**

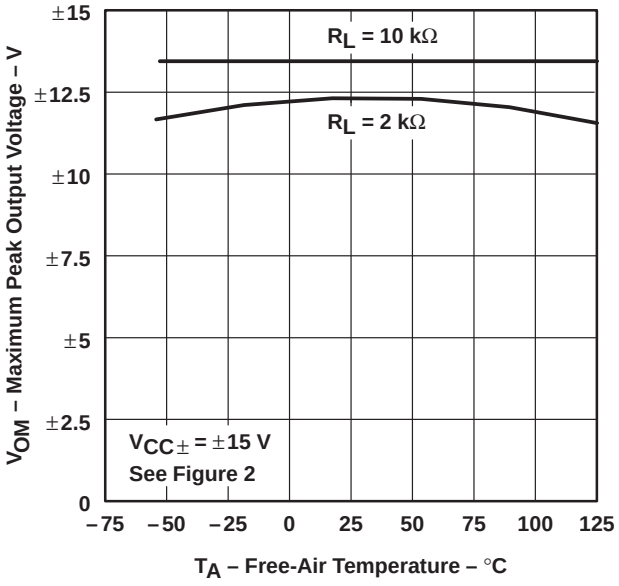



Figure 8

**MAXIMUM PEAK OUTPUT VOLTAGE vs LOAD RESISTANCE**

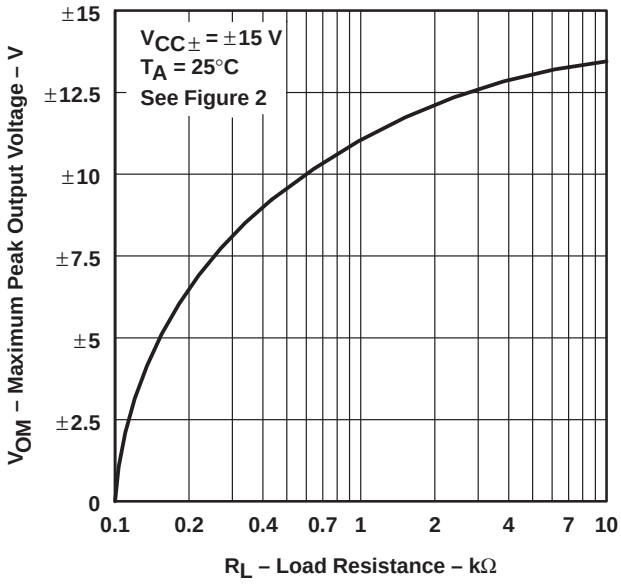



Figure 9

**MAXIMUM PEAK OUTPUT VOLTAGE vs SUPPLY VOLTAGE**

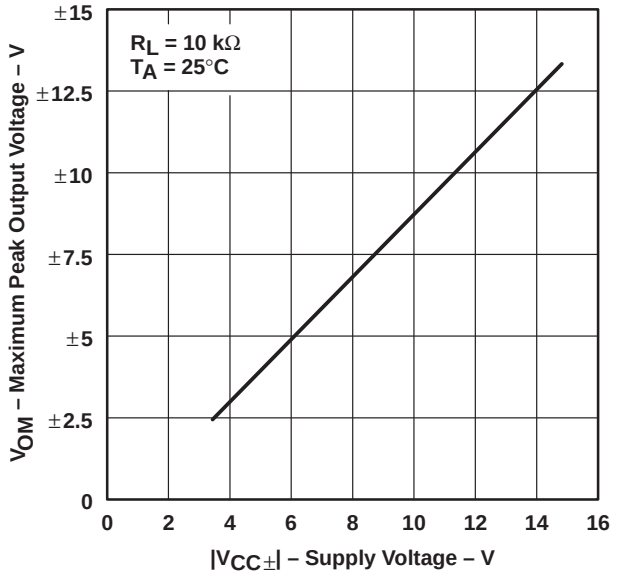



Figure 10

**LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs FREE-AIR TEMPERATURE**

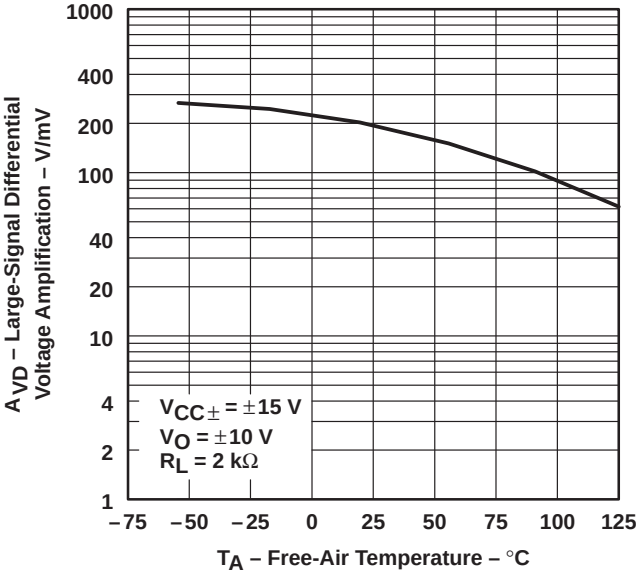



Figure 11

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

## TYPICAL CHARACTERISTICS†

**LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT vs FREQUENCY**

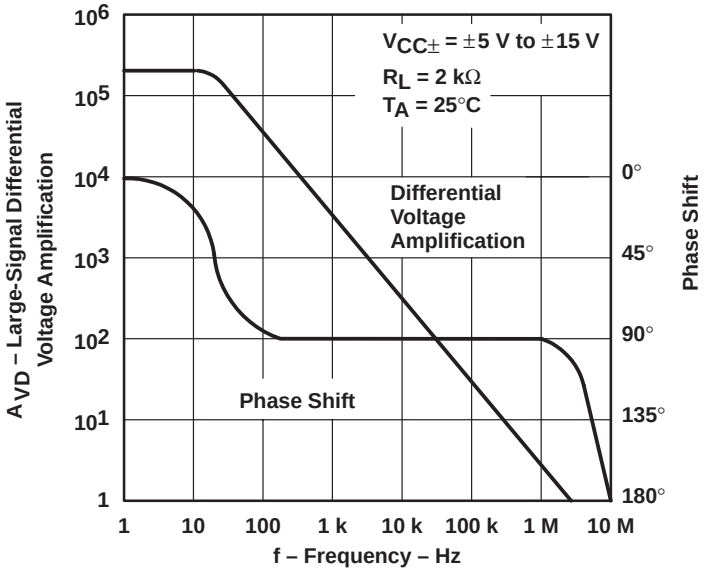



**Figure 12**

**NORMALIZED UNITY-GAIN BANDWIDTH AND PHASE SHIFT vs FREE-AIR TEMPERATURE**

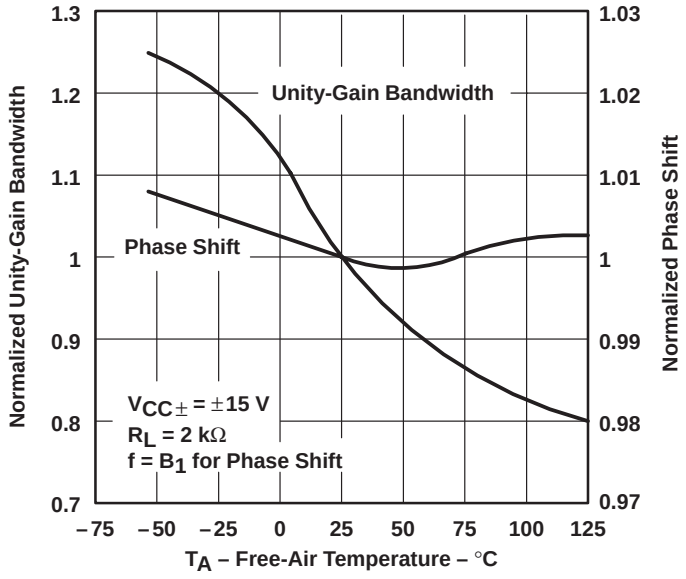



**Figure 13**

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

## TYPICAL CHARACTERISTICS†

**COMMON-MODE REJECTION RATIO vs FREE-AIR TEMPERATURE**

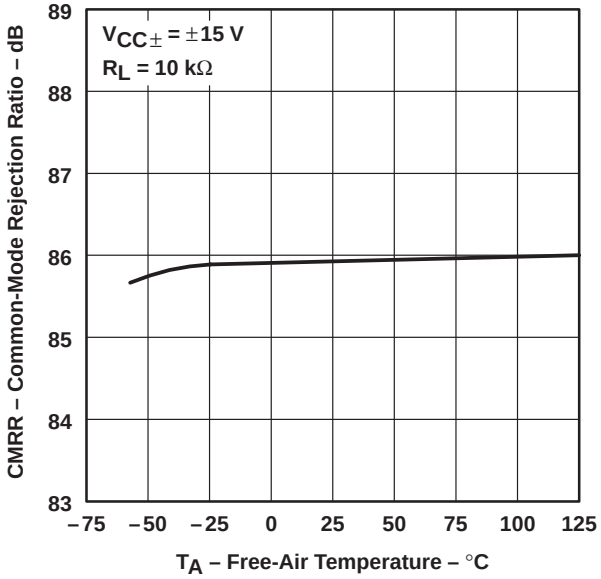



Figure 14

**SUPPLY CURRENT PER AMPLIFIER vs SUPPLY VOLTAGE**

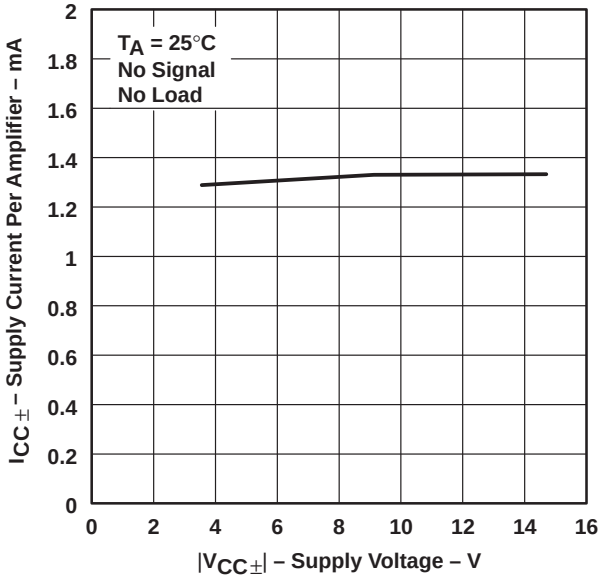



Figure 15

**SUPPLY CURRENT PER AMPLIFIER vs FREE-AIR TEMPERATURE**

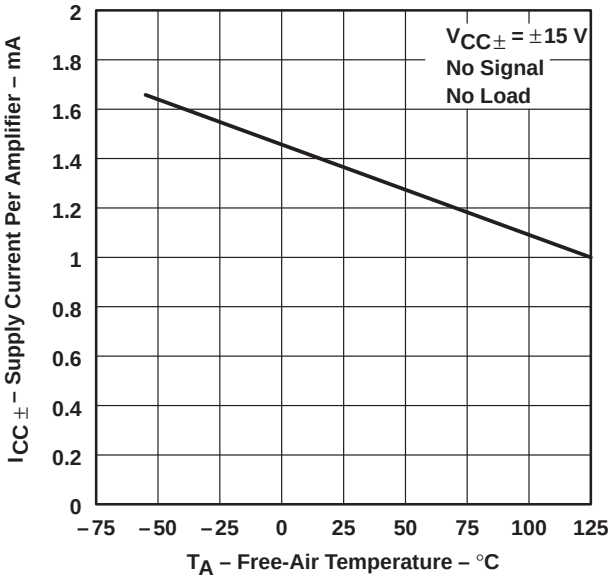



Figure 16

**TOTAL POWER DISSIPATION vs FREE-AIR TEMPERATURE**

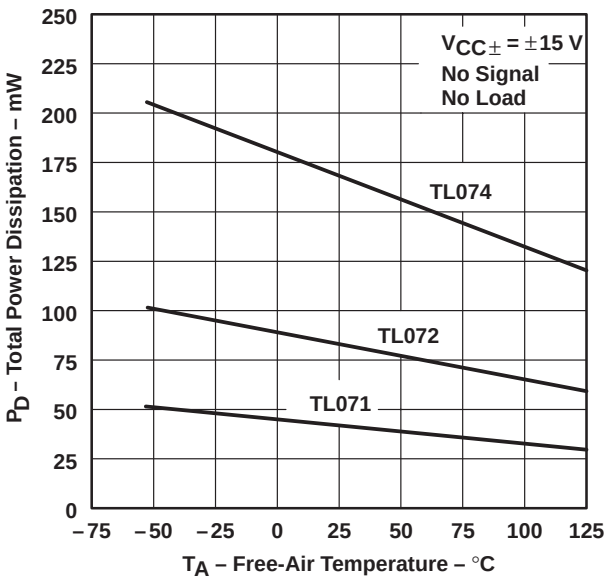



Figure 17

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

## TYPICAL CHARACTERISTICS

**NORMALIZED SLEW RATE vs FREE-AIR TEMPERATURE**

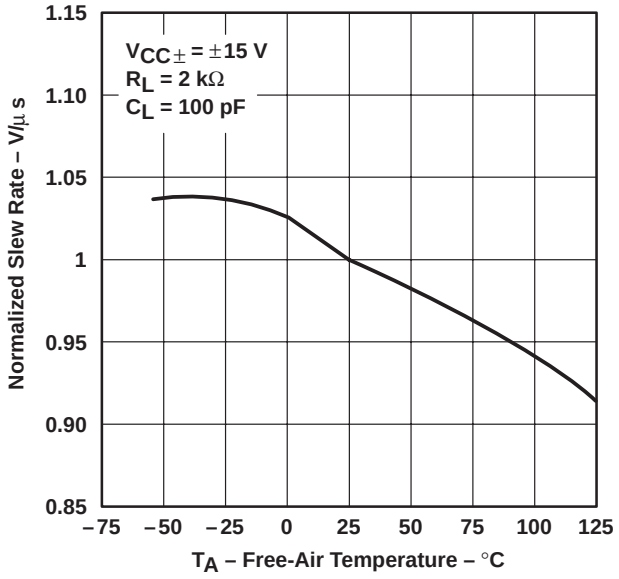



Figure 18

**EQUIVALENT INPUT NOISE VOLTAGE vs FREQUENCY**

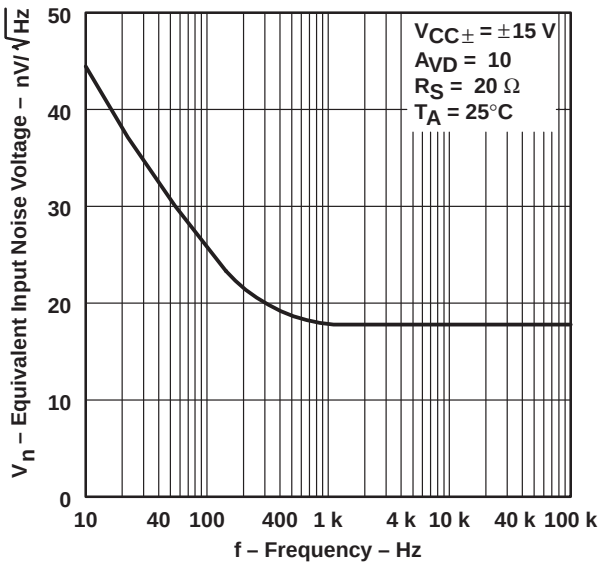



Figure 19

**TOTAL HARMONIC DISTORTION vs FREQUENCY**

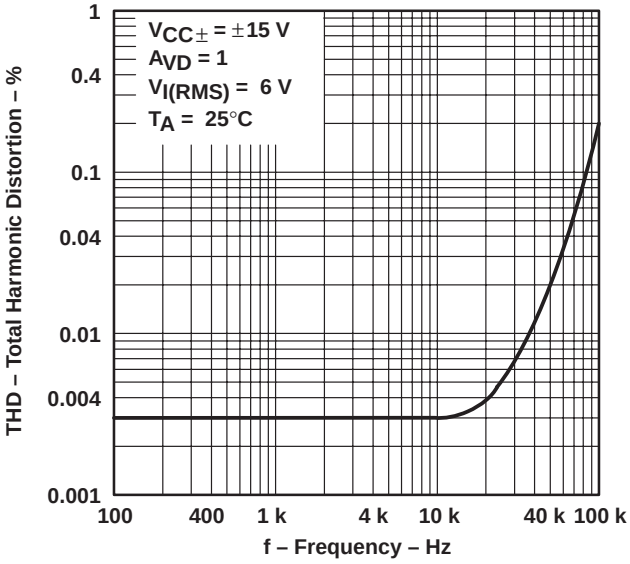



Figure 20

**VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE**

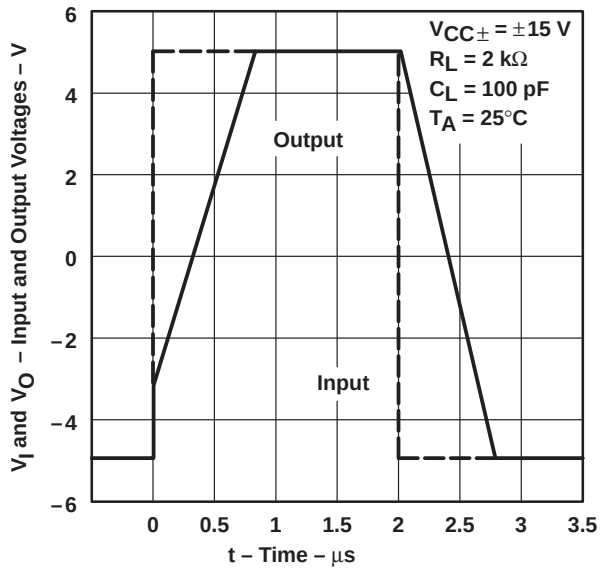



Figure 21

## TYPICAL CHARACTERISTICS

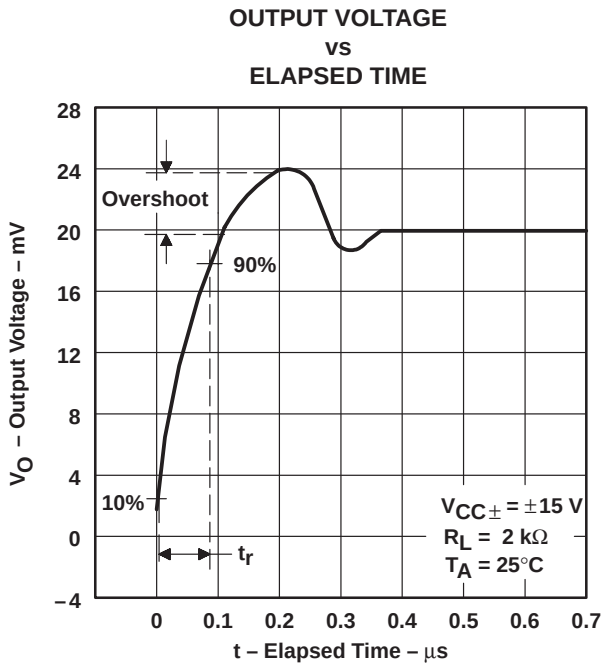



**Figure 22**

## APPLICATION INFORMATION

### Table of Application Diagrams

| APPLICATION DIAGRAM | PART NUMBER | FIGURE |
|---|---|---|
| 0.5-Hz square-wave oscillator | TL071 | 23 |
| High-Q notch filter | TL071 | 24 |
| Audio-distribution amplifier | TL074 | 25 |
| 100-kHz quadrature oscillator | TL072 | 26 |
| AC amplifier | TL071 | 27 |

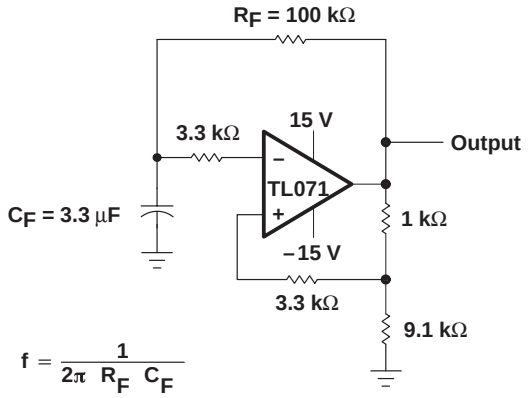



Figure 23. 0.5-Hz Square-Wave Oscillator

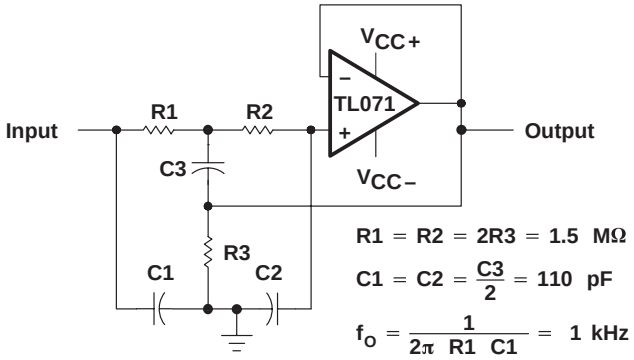



Figure 24. High-Q Notch Filter

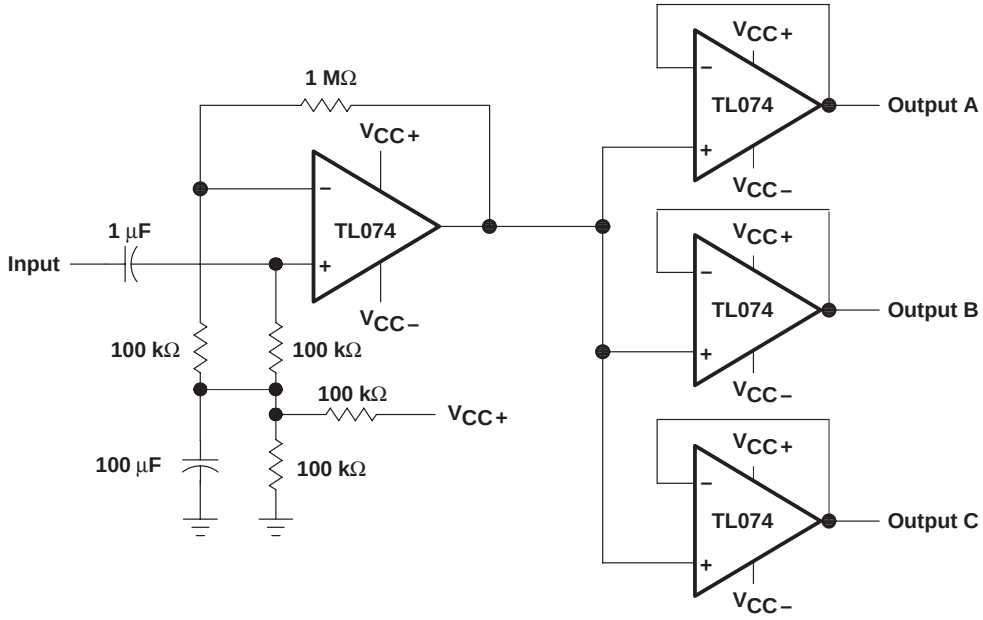
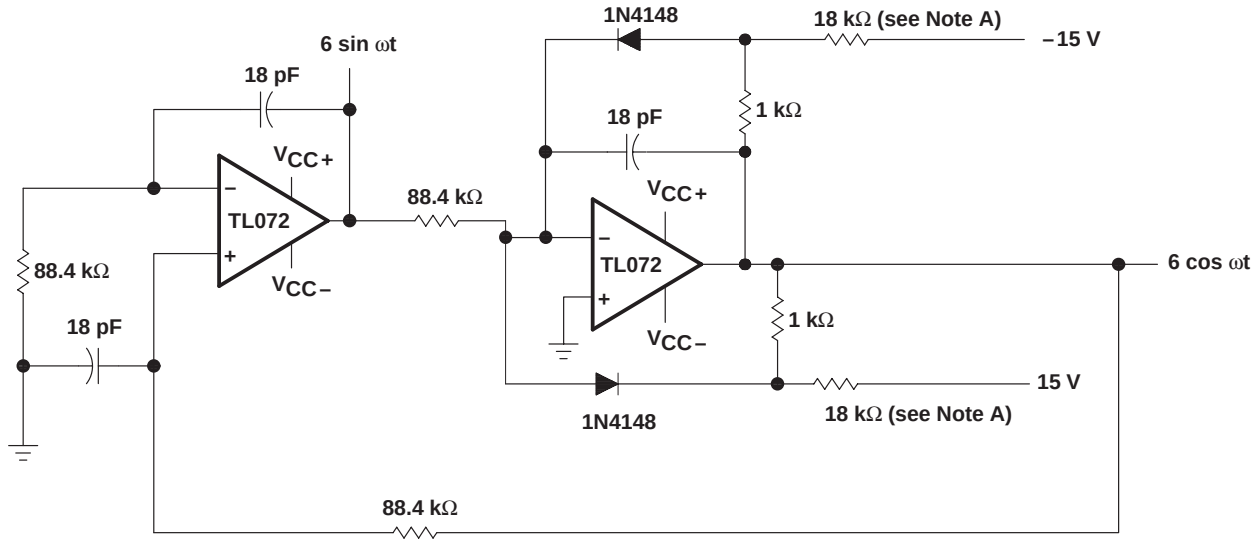



Figure 25. Audio-Distribution Amplifier

## APPLICATION INFORMATION




NOTE A: These resistor values may be adjusted for a symmetrical output.

**Figure 26. 100-kHz Quadrature Oscillator**

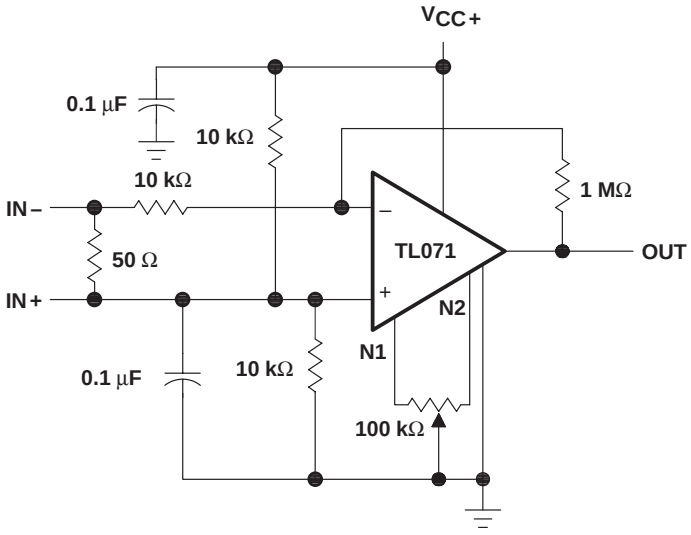



**Figure 27. AC Amplifier**

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